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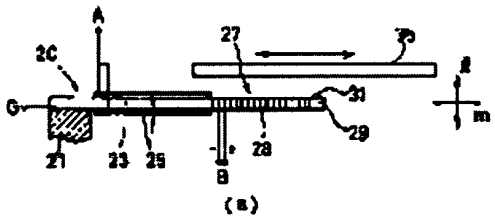
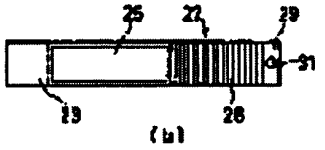
(54) ULTRASONIC OSCILLATOR AND DRIVER EMPLOYING THEREOF

(57)Abstract:

PURPOSE: To obtain a compact ultrasonic oscillator for facilitating design and manufacture by constituting the ultrasonic oscillator of a resilient member oscillating in first direction, a plurality of planar piezoelectric elements laminated on the resilient member in the oscillating direction thereof, and a laminate oscillating in second direction perpendicular to the first direction.





CONSTITUTION: An AC voltage having frequency equal to the resonance frequency in bending oscillation of an ultrasonic oscillator 20 is applied on an electric terminal A of a piezoelectric ceramics 25 stuck to a resilient body 23 thus generating resonant bending oscillation in one direction. On the other hand, several to several hundreds of piezoelectric ceramics boards, e.g. PZT, are laminated in the longitudinal direction on the end face at the opposite side to the fixing base 21 of the resilient body 23 to produce a piezoelectric laminate 27 having an electric terminal B, onto which an AC voltage having same frequency is applied to generate nonresonant longitudinal oscillation in the direction (m). when a phase difference is set appropriately between both AC voltages, a hemispherical protrusion 31 bonded to a protrusion base 29 undergoes ultrasonic elliptical oscillation. A slider 35 is then moved while regulating the elliptical oscillation lefthanded or righthanded.

LEGAL STATUS

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the driving gear which has the ultrasonic vibrator which used the electrical and electric equipment and machine sensing elements, such as a piezoelectric device, as the source of vibration, and this vibrator.
[0002]
[Description of the Prior Art] recently and electromagnetism -- the ultrasonic motor is in the limelight as a new motor which replaces a mold motor. Compared with the conventional motor, this ultrasonic motor not only says theoretically that it is new, but has the following advantages.
(1) They are a thin shape, a light weight, and a compact.
(2) A low speed and quantity torque are acquired without a gear.
(3) A bill of materials is simple and it is reliable.
(4) There is no transfer of magnetic effect.
(5) There is no backlash and positioning is easy.
[0003] Research of various applied technologies is advanced in order to employ these advantages efficiently in this way. An ultrasonic motor is roughly divided into a rotation mold and a linear mold. Drawing 13 - drawing 16 are drawings showing the conventional example of the ultrasonic motor of a linear mold.
[0004] Drawing 13 is drawing showing the 1st conventional example. The run undergarment mold piezoelectric transducer 1 of the left-hand side in drawing is vibrated, and if the tip of a horn 2 is attached and applied to the propagation rod 3 which consists of an elastic body, a crookedness progressive wave will occur on the propagation rod 3. The propagation rod 3 is spread rightward and this crookedness progressive wave goes, as the continuous-line arrow head D shows. And this progressive wave excites the run undergarment mold piezoelectric transducer 5 through the same horn 4 attached and hit to the right end of the propagation rod 3. L and R of drawing are chosen suitably, and carry out impedance matching, and all the energy of the above-mentioned progressive wave is made to absorb at this time. When it carries out like this, the above-mentioned progressive wave will always progress to the method of the right from a left regularly.
[0005] Now, if the front face of the propagation rod 3 which has produced such a crookedness progressive wave is made to carry out pressure-welding maintenance of the slider 6 by a certain fixed thrust, the slider 6 moves leftward in drawing, as the continuous-line arrow head H shows.
[0006] Drawing 14 is the perspective view showing typically the relation between the crookedness progressive wave of the above-mentioned propagation rod 3, and a slider 6. In addition, the elastic body with which 3in drawing A is equivalent to the propagation rod 3, and 6A are the mobiles equivalent to a slider 6. As shown in drawing 14 , the material point P of elastic body 3A is drawing the ellipse locus. Therefore, if the pressure welding of the mobile 6A is carried out by the predetermined pressure on elastic body 3A describing the elliptical orbit of the left-handed rotation in this drawing, mobile 6A will drive to hard flow, i.e., the left in drawing, with the travelling direction D of that progressive wave. In addition, if the propagation direction of a progressive wave is made reverse, mobile 6A will be driven in the direction of drawing Nakamigi.
[0007] Drawing 15 is drawing showing the configuration of other conventional examples. The oscillating piece 8 is attached at the tip of the run undergarment mold vibrator 7. And to slider 6B, the tip of the above-mentioned oscillating object 8 touches by fixed thrust, after only the predetermined include angle theta has inclined to the normal of the field of this slider 6B. If the alternating voltage of the same frequency as the natural frequency of a run undergarment mold trembler is impressed from AC power supply 9 to this run

undergarment mold trembler 7, the run undergarment mold trembler 7 will perform longitudinal oscillation. Since the tip of the oscillating piece 8 is in contact with slider 6B at the predetermined include angle theta at this time, transverse oscillation is also performed. The tip of the oscillating piece 8 draws an ellipse locus by composition of these vibration. In this way, slider 6B moves in the direction of Hidari, as the drawing Nakaya mark shows.

[0008] Drawing 16 is drawing showing still more nearly another conventional example, and shows the configuration of the vibrator indicated by JP,62-134278,A. Piezoelectric devices 11 and 12 have pasted both sides of the conductive vibrator 10 which makes the shape of a rectangle. From these piezoelectric devices 11 and 12, the lead terminals A and B for electrical-potential-difference impression are pulled out, and the earth terminal E is pulled out from vibrator 10. The configuration of vibrator 10 is the configuration the resonance frequency of the longitudinal oscillation of this vibrator 10 and whose resonance frequency of flexural oscillation correspond. If the alternating voltage which has the above-mentioned resonance frequency is impressed to the above-mentioned lead terminals A and B with fixed phase contrast in this way, the material point of the end face S of vibrator 10 will perform ellipse movement. Then, if slider 6C is pressed by the fixed pressure to the above-mentioned end face S, this slider 6C will move towards the drawing Nakaya mark HH. This migration direction is determined by the phase contrast of the electrical potential difference impressed to Terminal A and Terminal B.

[0009]

[Problem(s) to be Solved by the Invention] The ultrasonic motor shown in drawing 13 - drawing 16 makes it radical Motohara ** to transmit the ellipse locus kinetic energy in the material point of vibrator to a mobile (slider) by friction.

[0010] In the 1st conventional example shown in drawing 13 , in order to have to make the whole propagation rod 3 generate a progressive wave, there was a problem that the whole equipment will be enlarged, the top where effectiveness is bad.

[0011] Moreover, in the 2nd conventional example shown in drawing 15 , when the travelling direction of slider 6B was limited to an one direction, there was a problem that the whole equipment will be enlarged like the 1st conventional example.

[0012] Furthermore, since it is what obtains an oscillating output by the piezoelectric devices 11 and 12 pasted up on both sides of vibrator 10 in the 3rd conventional example shown in drawing 16 , it is difficult to secure the big force for moving slider 6C. When the number of sheets of the piezoelectric devices 11 and 12 pasted up on the side face of the above-mentioned vibrator 10 was increased in order to obtain a bigger oscillating output, only the part had the fault that equipment will be enlarged. Moreover, although this conventional example tends to compound the longitudinal oscillation of vibrator 10, and flexural oscillation and it is going to generate ellipse vibration, a big output is not obtained unless all both vibration is the resonance state. Therefore, it is necessary to make in agreement the resonance frequency of longitudinal oscillation, and the resonance frequency of flexural oscillation. For this reason, the configuration of vibrator 10 had to be decided in the try and the error, the big effort was required, and there was a problem that manufacture was not easy.

[0013] the case where the purpose of this invention was compact, and the energy conversion efficiency was good, could take out the oscillating output big moreover, and it uses as a linear motor -- a drive object -- the constraint a, reversibly movable top and on a design -- few -- manufacture -- it is in offering the driving gear which has an easy ultrasonic vibrator and this vibrator.

[0014]

[Means for Solving the Problem] In order to solve said technical problem, a piezoelectric device is prepared and the ultrasonic vibrator of this invention is characterized by to have the layered product which can vibrate in two or more sheet laminating, and the 1st direction and the 2nd direction which intersects perpendicularly, and a means control vibration of said 1st direction, and vibration of the 2nd direction by making it fix in the direction in which said elastic body vibrates a tabular piezoelectric device to the elastic body which can vibrate in the 1st direction, and this elastic body.

[0015] Furthermore, in order to solve said technical problem, the driving gear of this invention has said ultrasonic vibrator, at least one projection member which is formed in this ultrasonic vibrator and achieves ellipse movement, and the moving-part material by which press contact is carried out at this projection member, and is characterized by constituting so that this moving-part material may be moved in the direction of a flat surface of arbitration.

[0016]
[Function] The same frequency fr as the crookedness resonance frequency which the joined ultrasonic vibrator has in the piezoelectric device stuck on the side face of an elastic body The alternation electrical potential difference of the same frequency is impressed, and resonance crookedness vibration is generated. In it, it is the same frequency fr. An alternation electrical potential difference is impressed to a piezo-electric layered product, and an ultrasonic vibrator is made to generate the longitudinal oscillation of dissonance. By giving phase contrast suitably about the phase of the alternation electrical potential difference impressed to the phase and the piezo-electric layered product of an alternation electrical potential difference which are impressed to the piezoelectric device stuck on the side face of an elastic body, the projection object in a projection base performs ultrasonic ellipse vibration. The ellipse vibration is adjusted so that it may become a RLC or a RRC, and the mobile which carried out the pressure welding to the projection object is made to slide.
[0017]
[Example] Hereafter, the example of this invention is concretely explained along with an accompanying drawing.
(The 1st example)
[0018] The side elevation showing the configuration of the ultrasonic vibrator 20 which drawing 1 (a) requires for this invention, and (b) are the top view. A sign 23 shows the elastic body constituted from a rectangle by plate-like [thin]. This elastic body 23 is constituted by metallic materials, such as stainless steel, phosphor bronze, and aluminum. Moreover, an elastic body 23 is set at the edge, and is being pasted up and fixed on the mount 21. The electrostrictive ceramics (piezoelectric device) 25, such as rectangle tabular PZT, has pasted the vertical side of an elastic body 23 with the adhesives of an epoxy system, respectively. The piezo-electric layered product 27 to which hundreds of several - sheet laminating of the electrostrictive ceramics plates 28, such as PZT, was carried out towards the longitudinal direction has pasted said mount 21 of an elastic body 23, and the end face of the opposite side. The laminating of the electrostrictive ceramics plate 28 which constitutes the piezo-electric layered product 27 is carried out by adhesives, such as epoxy, so that the direction of polarization may become reverse by turns.
[0019] As for the front face of the electrostrictive ceramics 25 pasted up on the elastic body 23, electrotreatment is performed by for example, baking silver, and polarization of the electrostrictive ceramics 25 is carried out beforehand. As for the direction of polarization, double-sided electrostrictive ceramics serves as facing up (or facing down of a Fig. [electrostrictive ceramics / double-sided]) of a Fig. The electric terminal A is taken out from each electrode surface of electrostrictive ceramics 25, and the electric terminal B is taken out from said piezo-electric layered product 27. If a forward electrical potential difference is impressed to + terminal of this electric terminal B, the piezo-electric layered product 27 is designed so that it may be extended. Moreover, the elastic body 23 is grounded in the edge.
[0020] Furthermore, the projection base 29 which consists of metallic materials, such as stainless steel, has pasted the end face of the longitudinal direction of the piezo-electric layered product 27. The semi-sphere-like projection object 31 protrudes in the adhesion direction of an elastic body 23, the piezo-electric layered product 27, and the projection base 29, and the direction which intersects perpendicularly, and this projection object 31 is formed in the top face of this projection base 29 in one with the projection base 29. This projection object 31 is raising abrasion resistance by heat treatment hardening. In addition, in the configuration of drawing 1 , drawing 1 of the junction to an elastic body 23 and the piezo-electric layered product 29 may be a reverse order.

[0021] The tabular slider 35 has fixed thrust in the front face of said projection object 31, and it is in contact in the direction of an arrow head movable. The press device equipped with the koro which is not illustrated and a spring, for example can constitute this. That is, a slider 35 can contact movable to the projection object 31 by arranging the koro between the springs and sliders which energize a slider 35 downward. In addition, as for this slider 35, alumite processing is performed on the surface of aluminum. Next, an operation of the driving gear which has this ultrasonic vibrator 20 and this vibrator is explained.
[0022] The alternation electrical potential difference of the same frequency as the resonance frequency of crookedness vibration of this ultrasonic vibrator is impressed to the electric terminal A of electrostrictive ceramics 25 stuck on the elastic body 23, and an ultrasonic vibrator is made to generate vibration of the direction of l. On the other hand, the electric terminal B of the piezo-electric layered product 27 is made to generate vibration of the direction of m by impressing the alternation electrical potential difference of the same

frequency as it. This vibration is dissonance vibration. In this case, said projection object 31 performs vibration as shown in drawing 2 (a) - (d) by taking the phase contrast of both electrical potential differences suitably.
[0023] As mentioned above, the slider 35 touches the projection object 31. While performing vibration as the projection object 31 shows to drawing 2 (b), a slider 35 moves to the right-hand side of drawing, and while performing vibration as shown in drawing 2 (d), a slider 35 moves to the left-hand side of drawing. That is, according to this example, the thing of a configuration very thin as a linear actuator can be obtained.
(The 2nd example) The 2nd example of this invention is explained based on drawing 3 thru/or drawing 5 .
[0024] Drawing 3 is the side elevation showing the configuration of an ultrasonic vibrator. In addition, in the following examples, the same part as the 1st example attaches the same sign, and omits the explanation. The difference to the 1st example is a point which the electrostrictive ceramics 26, such as PZT for feedback which detects the vibration, has pasted up with epoxy system adhesives on some elastic bodies 23 (a part of inferior surface of tongue of an elastic body 23). The front face of this electrostrictive ceramics 26 can also be burned, electrotreatment is performed with silver etc., and the electric terminal F for feedback is picked out from that electrode. The condition (the amplitude, phase) of crookedness vibration of an ultrasonic vibrator 20 is detected by the piezoelectric device 26 for feedback, and it is constituted so that the vibration may become the optimal and feedback may be applied to a drive circuit.
[0025] An example of a configuration of applying feedback to the drive circuit which drives the ultrasonic vibrator 20 applied to this invention at drawing 4 is shown. The output from a feedback terminal is first amplified with amplifier. The output voltage of amplifier is rectified by the rectifier circuit 41, and the feedback voltage proportional to the amplitude of the vibration (crookedness vibration) is fed back to an oscillator circuit 42. This dispatch circuit 42 always changes that oscillation cycle, and it sets up an oscillation frequency so that previous feedback voltage may serve as max. That is, crookedness vibration is performed on the frequency from which the amplitude of crookedness vibration always serves as max. On the other hand, feedback voltage is inputted into the phase detector 43 with an oscillation voltage signal, and the phase contrast is detected here. The phase contrast signal is inputted into a phase-shifting circuit 44, and it is adjusted here so that the phase contrast of the phase of feedback voltage and the phase of the voltage signal impressed to a battery terminal may become +90 degrees or -90 degrees. Since the piezo-electric layered product 27 is dissonance vibration, with input voltage, it is almost in phase and vibrates. Therefore, the projection object 31 will perform ultrasonic ellipse movement of a clockwise rotation or a half-clockwise rotation.
[0026] The drive circuit of another example is indicated to be the drive circuit shown in drawing 5 at drawing 4 . The output from a feedback terminal is first amplified with amplifier, and the electrical potential difference is inputted into phase detector 43a with the oscillation voltage signal from oscillator-circuit 42a. And both phase contrast is detected. The phase contrast signal is fed back to oscillator-circuit 42a. This oscillator-circuit 42a always changes that oscillation frequency, and it adjusts an oscillation frequency that previous phase contrast should always be considered as regularity (for example, 90 degrees) so that crookedness vibration may always be the resonance state. On the other hand, a phase contrast signal is inputted into phase-shifting circuit 44a, and it is adjusted so that the phase contrast of the phase of feedback voltage and the phase of the voltage signal impressed to a battery terminal may become +90 degrees or -90 degrees. Consequently, the projection object 31 will perform ultrasonic ellipse movement of a clockwise rotation or a half-clockwise rotation.
(The 3rd example)
[0027] Drawing 6 is the side elevation showing the configuration of the 3rd example of an ultrasonic vibrator. Unlike the 1st example, it is constituted so that the cross-section configuration of an elastic body 23 may differ from the cross-section configuration of a layered product 27. Thus, even if constituted, the same effectiveness as the 1st example can be acquired. In addition, the terminal and the slider are omitted in this drawing.
(The 4th example)
[0028] Drawing 7 (a) and (b) are the side elevations and top views showing the configuration of the 4th example of an ultrasonic vibrator. This example connects to a two-piece serial the ultrasonic vibrator explained in said 1st example, and is constituted. However, as for each ultrasonic vibrator 20a and 20b, unlike the 1st example, the junction sequence of a piezo-electric layered product and an elastic body is reverse. The holddown member 30 which connects two ultrasonic vibrators 20a and 20b is formed from metal members, such as stainless steel, and adhesion immobilization is carried out at the mount 21. Piezo-electric layered product 27of ultrasonic vibrator 20a a vibrates in the direction of b in drawing, and elastic body 23a vibrates in the direction of a in drawing. Piezo-electric layered product 27of ultrasonic vibrator 20b b vibrates in the direction of d in

drawing, and elastic body 23b vibrates in the direction of c in drawing. In this way, each projection object 31a and 31b can perform ultrasonic ellipse vibration.

[0029] Next, an operation of the driving gear using this ultrasonic vibrator and this is explained. Left projection object 31a and right projection object 31b are made to produce ultrasonic ellipse vibration of the respectively same clockwise rotation or a half-clockwise rotation by the drive approach stated to the 1st example. In this case, the tabular slider 35 is contacted on the front face of the projection objects 31a and 31b movable in the direction of an arrow head with fixed thrust like the 1st example. Then, a slider 35 is movable in the direction of an arrow head with ellipse movement of each projection object 31a and 31b.

[0030] Or things are also considered making it be the following. When moving a slider 35 leftward, an electrical potential difference is impressed only to piezoelectric-device 25b which left projection object 31a was made to produce ultrasonic ellipse vibration of a half-clockwise rotation, and was stuck on right projection object 31b at right elastic body 23b, and only migration of the direction of c of drawing is generated. When moving a slider 35 rightward, an electrical potential difference is impressed only to piezoelectric-device 25a which right projection object 31b was made to produce a clockwise ultrasonic ellipse vibration, and was stuck on left projection object 31a at left elastic body 23a, and only migration of the direction of a of drawing is generated. Thus, in order that tensile force may not work to layered products 27a and 27b although the power as vibrator becomes small when driving a slider 35, the endurance of an ultrasonic vibrator can be raised.

(The 5th example)

[0031] Drawing 8 is the top view showing the configuration of the 5th example of an ultrasonic vibrator. Four of this example are constituted using the ultrasonic vibrator explained in said 1st example, and each ultrasonic vibrator 20a-20d is arranged at the include angle which makes 90 degrees through holddown-member 30a. A pressure welding is carried out by the fixed thrust which has the slider which is not illustrated in the space upper part of this ultrasonic vibrator.

[0032] When moving this slider that is not illustrated to the longitudinal direction in drawing, a slider is made to drive using vibrator 20a and vibrator 20b, as the 4th example explained. In this case, the vibrator 20c and 20d is [both] in the condition that crookedness vibration is carried out. Moreover, when moving the slider which is not illustrated to drawing Nakagami down, a slider is made to drive using vibrator 20c and 20d of vibrator, as the 4th example explained. In this case, the vibrator 20a and 20b is [both] in the condition that crookedness vibration is carried out. Furthermore, if the amplitude of each supersonic vibration is adjusted using Vibrator 20a-20d, it will become possible to move within space the slider which is not illustrated two-dimensional.

(The 6th example)

[0033] Drawing 9 (a) and (b) are the side elevations and front views showing the configuration of the 6th example of an ultrasonic vibrator. The piezo-electric layered product 27 and the elastic body 23 are constituted in the shape of a rectangular parallelepiped, and these have pasted up this example both. And as shown in (b), the projection objects 31a-31e are formed in all the external surface for a point of an elastic body 23, respectively. Moreover, the piezoelectric device 25 is stuck on each side of an elastic body 23. It is possible to make every projection object generate ultrasonic ellipse vibration, and it becomes possible to move a slider in the field corresponding to each projection object by carrying out the pressure welding of the slider to a required projection object so that clearly [the explanation mentioned above]. That is, the part applicability will spread.

(The 7th example) Drawing 10 is the perspective view showing the configuration of the 7th example of an ultrasonic vibrator.

[0034] This example has the piezo-electric layered product 27 which piled up several - dozens of electrostrictive ceramics 28, such as PZT formed in disc-like [thin], so that the direction of polarization might become reverse by turns. The elastic body 24 of the same configuration is being fixed to the upper limit of this piezo-electric layered product 27. this elastic body 24 top ** -- adhesion immobilization of the elastic body 23 mostly formed in the center section in the shape of a rectangular parallelepiped is carried out towards the direction of a vertical. The piezoelectric device 25 is stuck on each side face of an elastic body 23, respectively, and the projection object 31 which achieves ultrasonic ellipse movement is formed in the upper limit side.

[0035] In this example, if resonance crookedness vibration is generated, in order that the part of an elastic body 23 may perform crookedness vibration, stress is seldom applied to the piezo-electric layered product 27, but endurance improves.

(The 8th example)

[0036] Drawing 11 is the perspective view showing the configuration of the 8th example of an ultrasonic

vibrator. As compared with the example of drawing 10 , an elastic body 23 is formed in plate-like [rectangular], and it differs in that the piezoelectric device 25 was stuck on the both sides. Thus, even if constituted, the same effectiveness as said 7th example can be acquired.

(The 9th example)

[0037] Drawing 12 (a) and (b) are the perspective views and top views showing the configuration of the 9th example of an ultrasonic vibrator. In this example, while attaching the cylinder-like elastic body 23 on the piezo-electric layered product in said 7th example, a part for a notch is formed in four places of the peripheral face of that interstitial segment so that the field of a right angle may be accomplished mutually. That is, the interstitial segment of an elastic body 23 is mostly formed in the shape of a cube, and the piezoelectric device 25 is stuck on each field. Thus, even if constituted, the same effectiveness as said 7th example can be acquired.

[0038] As mentioned above, although this invention was explained using various examples, as for this invention, it is needless to say for deformation implementation to be variously possible in the range which is not limited to each example mentioned above and does not deviate from the summary of this invention.

[0039]

[Effect of the Invention] In order that the ultrasonic vibrator of this invention may form ultrasonic ellipse vibration by compounding dissonance vibration and resonance vibration which intersect perpendicularly mutually, the ellipse amplitude of the configuration of arbitration is obtained. For this reason, while the design of an ultrasonic vibrator becomes easy, a very compact ultrasonic vibrator can be obtained.

[0040] Furthermore, by using such an ultrasonic vibrator, an energy conversion efficiency is good, manufacture is easy, and the driving gear of a thin form and a compact configuration can be obtained. Furthermore, a drive object is reversibly movable.

[Translation done.]

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【図1】（a）は、本発明の第1の実施例の構成を示す側面図、（b）はその平面図である。

【図2】（a）～（d）は、それぞれ本発明の超音波振動子の突起体の移動軌跡を示す図である。

【図3】本発明の第2の実施例の構成を示す側面図である。

【図4】本発明に係る超音波振動子を駆動する駆動回路に、フィードバックをかける構成の一例を示す図。

【図5】本発明に係る超音波振動子を駆動する駆動回路に、フィードバックをかける構成の図4とは別の例を示す図。

【図6】本発明の第3の実施例の構成を示す側面図である。

【図7】（a）は、本発明の第4の実施例の構成を示す側面図、（b）はその平面図である。

【図8】本発明の第5の実施例の構成を示す平面図である。

【図9】（a）は、本発明の第6の実施例の構成を示す＊側面図、（b）はその正面図である。

【図10】本発明の第7の実施例の構成を示す斜視図である。

【図11】本発明の第8の実施例の構成を示す斜視図である。

【図12】（a）は、本発明の第9の実施例の構成を示す斜視図、（b）はその平面図である。

【図13】従来の超音波リニアモータの構成を示す図である。

【図14】同従来例の弾性体に生じる進行波を示す図である。

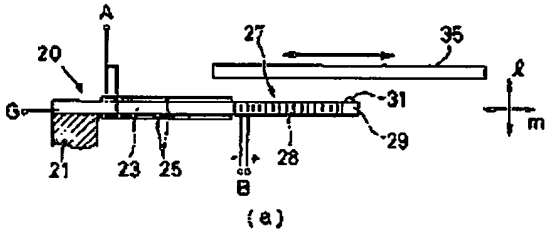
【図15】他の従来例の構成を示す図である。

【図16】さらに別の従来例の構成を示す図である。

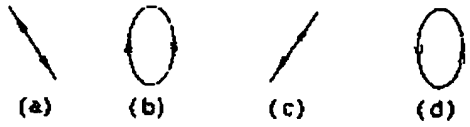
【符号の説明】

20…超音波振動子、23…弾性体、25…圧電素子、27…圧電積層体、31…突起体、35…スライダ（可動部材）。

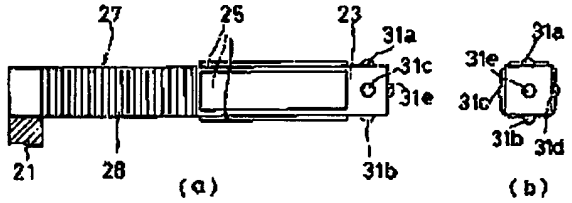
【図1】



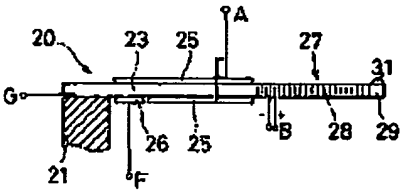
【図2】



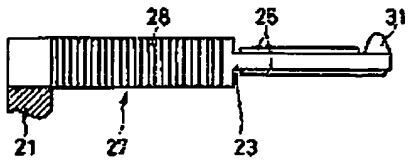
【図9】



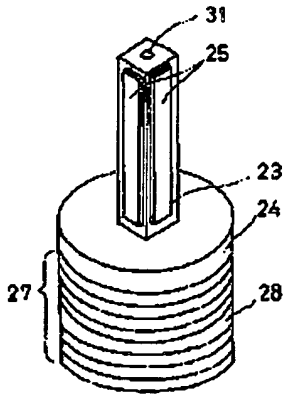
【図3】



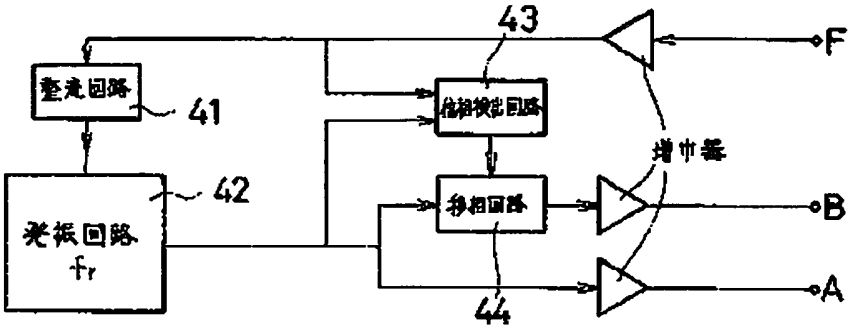
【図6】



【図10】



【図4】



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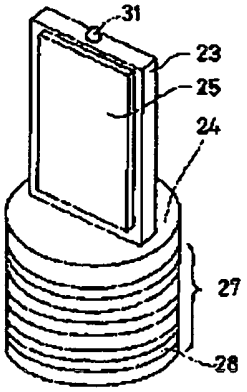

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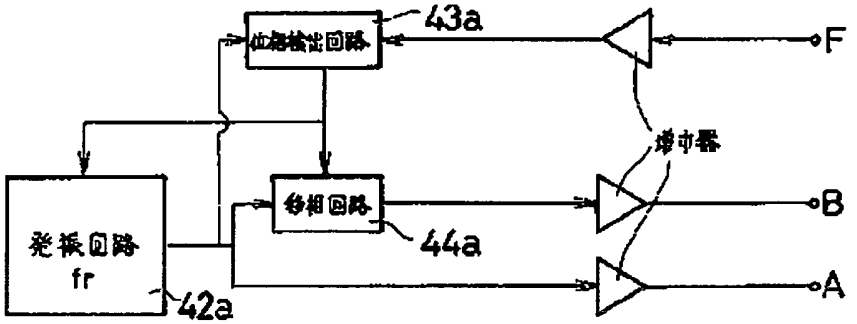

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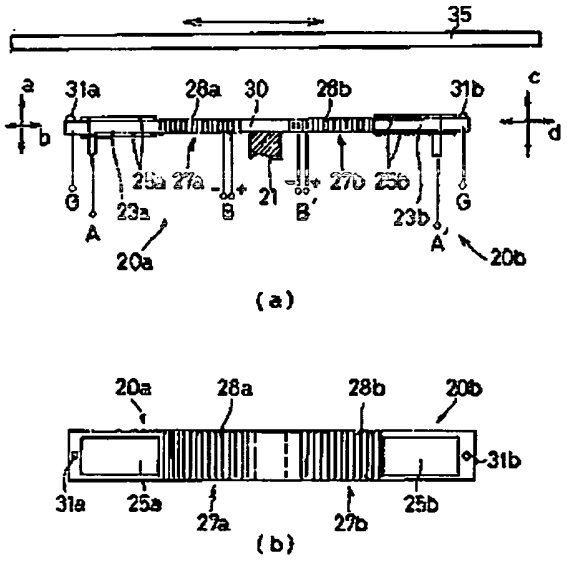

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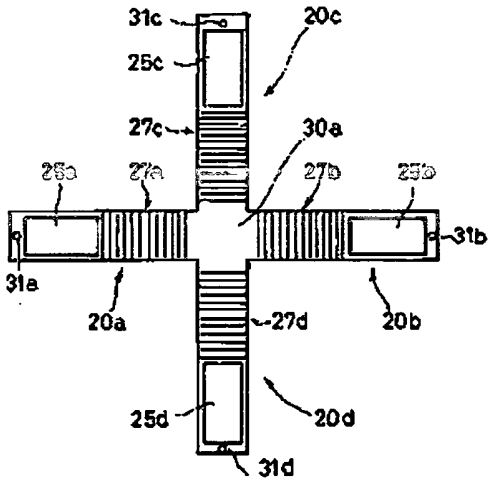

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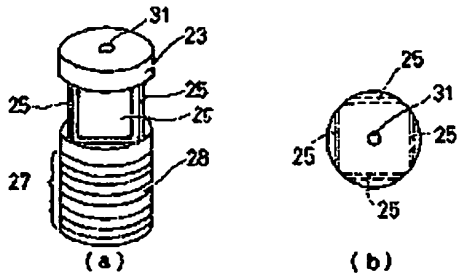

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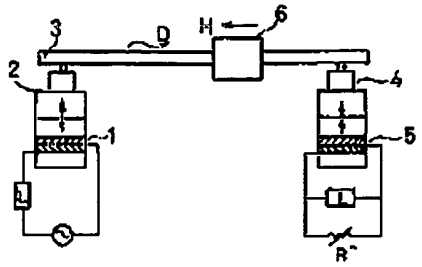

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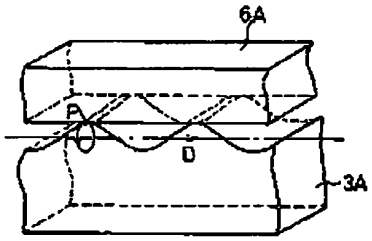

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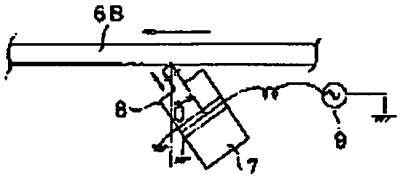

【図16】